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ABSTRACT

Available on the University of Illinois PLATO IV Computer system, the Population Dynamic Group computer-aided instruction program for teaching population dynamics is described and explained. The computer-generated visual graphics enable fast and intuitive understanding of the dynamics of population and of the concepts and data of population. The basic program is a population projection model which can forecast the population of over 120 countries, based on either constant or changing 1970 demographic parameter assumptions. Basic data are 1970 total population, age composition categorized into 18 five-year intervals, period age specific fertility rates, and a cohort specific mortality rate schedule. Other programs in the series contribute additional parameters including economic development, educational development, food demand and supply, energy demand, labor force analysis, migration and urbanization, population history, and birth control use. These materials explain how to use the system; provide information on concepts, definition, and the program algorithms; and provide suggestions for the practical applications of the program. (Author/DE)

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REPORT T-19 AUGUST, 1975

CSL COORDINATED SCIENCE LABORATORY

**COMPUTER ASSISTED INSTRUCTION
OF POPULATION DYNAMICS:
A NEW APPROACH
TO POPULATION EDUCATION**

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U.S. DEPARTMENT OF HEALTH
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INTRODUCTION

At a time when a great deal of attention is being focused on the issue of worldwide population growth and the relationship between population and food, energy and environmental issues, one of the major problems facing the field of population education is the question of how to communicate the complexities of population dynamics in a meaningful way. The context of this problem ranges from awareness to instruction and finally to population policy.

It has been suggested by authorities in the field of family planning (Berelson, 1969) and in the wider field of social demography (Davis, 1967) that the solutions to population problems lie beyond family planning programs. Population education is seen, not as an alternative to family planning, but as a complimentary activity. Lane and Wileman in A Structure for Population Education state that "Population Education is the study of human population and how population affects and is affected by several aspects of life: physical, social, cultural, political, economic and ecological". (1974:6).

Simmons (1970) in a review of the field of population education states that four educational approaches have been suggested: sex education, education for family planning, population awareness and basic value orientation.

Any attempt here to define and justify the need for population education and the need for ways of improving communication seems superfluous. This task has already been covered in numerous appeals for improved and expanded efforts at population education. (Viederman, 1972; Population Reference Bureau Bulletin, Vol. XXVI, 3; Burleson, 1969; Science for Society, Vol. 2, Number 4; Simmons, 1970). It does seem, however, that the field of popula-

tion education has been slow in utilizing the developments in computer-based education technology for the purposes of transmitting information. In a research review of teaching population at the undergraduate level on campuses, Rogers and Bauman (1974) make little or no reference to the use of computers as teaching aids. The reason for this lack of computer use is not clear, but it is highly likely that an instructor does not have the resources nor the time to acquaint students with the procedure to use the computer under traditional methods of utilization of computer services. Computer technology has provided techniques for the speedy and efficient analysis of large amounts of data. But, in addition to research and analytical capabilities, the computer is increasingly being utilized in the field of education. (Hammond, 1972; Bitzer, et al., 1973).

Whereas initial attempts to use the computer in instruction were restricted to the selection of answers in a multiple choice framework, recent developments permit the creation of computer-aided instruction (CAI) systems with much greater levels of flexibility and creativity. This paper describes and explains the Population Dynamics Group (PDG) computer-aided instruction program for teaching population dynamics. The program is designed to utilize innovations in computer technology to provide the user - student and teacher - with a method for lowering the information threshold which traditionally hampers the internalization of complex subject matter. Use is made of computer-generated visual graphics to enable fast and intuitive understanding of the dynamics of population and of the concepts and data of population. The objective is to strive for a computer-assisted instruction system which will enable students and teachers to conceptualize the relevance of population and to learn the importance of population data in

the context of problems or issues with which they are dealing.

THE COMPUTER SYSTEM

The computer-assisted instruction (CAI) programs described in this paper are available on the University of Illinois PLATO IV system. (Wood, n.d.). PLATO IV consists of a visual interactive graphics terminal, hooked up to a central computer which reacts instantly to the commands of the user by displaying the requested material at the terminal. The computer used for the PLATO system is a Control Data Corporation Cyber 73-24 with 65,000 sixty-bit words of central memory, two central processors (CPU's), several disk storage units, and ten peripheral processing units (PPU's). The terminal consists of a plasma display panel having pictorial and graphic capabilities with the memory at the display unit inherent to the panel, and a keyboard used for execution of the programs as well as authoring of the programs. (Stifle, 1973). The PDG population simulation program described in this paper is one of the many programs available in the PLATO system. (Grandey, 1970; Hyatt, 1972; Lyman, 1974).

In addition to the University of Illinois PLATO IV system, a number of other system options exist for utilizing the PDG programs. The programs are operational on a Data General 1200/J minicomputer which is independent of the PLATO system. The use of minicomputers in CAI is becoming increasingly evident in education (Su and Emam, 1975; Attala, 1974). It is also possible to make the PDG program available for use on any computer with Interactive BASIC computer language which is linked to a graphics terminal. For example, a DEC System 10 and a Tektronic 4010 terminal have been successfully used to display the PDG program. Finally a PLATO system

comparable to that in Illinois has been established at Florida State University and the program should be fully operational on that system (Merrill et al., 1975). Thus, while the PDG program described here is available at the approximately 800 terminals throughout the country linked to the Illinois system, the program can be made more generally available through one or other of the above mentioned systems.

THE PROGRAM

In the area of Population Dynamics, two series of lessons are available: DEMTEC and POPSOC. DEMTEC is a series of methodology programs designed to teach the concepts of demography and the basic techniques of demography which are utilized in the POPSOC series. A list of the DEMTEC and POPSOC programs can be found in Table 1. The POPSOC series are designed to produce projections of population data, and to relate population data to other elements in what Duncan (1959) has called "the Ecological Complex". In addition, the POPSOC programs are extremely useful in teaching demographic methodology through practical application. Detailed descriptions of each POPSOC program are contained in program commentaries. The major purpose of these commentaries is to familiarize the user with the theoretical and technical aspects of each program. The programs are designed to fulfill the needs of persons with varying educational skills and degrees of demographic training.

This paper deals mainly with the Population Projection Program. For the description of the program and the model, see Klaff (1975), Population Projection Commentary.

TABLE 1

List of DEMTEC and POPSOC
Programs

A. DEMTEC Programs

1. The Life Table
2. How to Project a Population
3. Standardization
4. The Demographic Equation
5. Population Workbook

B. POPSOC Programs

1. Population Projection (Combined Sex Model)
2. Population Projection (Two-Sex Model)
3. Economic Development
4. Educational Costs and Enrollment
5. Food Demand and Supply
6. Demand for Energy
7. Labor Force Analysis
8. Migration and Urbanization
9. Population History
10. Contraceptive Coverage

The Basic Model

The basic model for the PDG series of programs is a population projection model which can project the population of over 120 countries, based on either constant or changing 1970 demographic parameter assumptions. The model is based on the matrix projection procedure outlined by Keyfitz, Introduction to the Mathematics of Population (1968). The most important equations of the model may be found in Keyfitz, chapter 2.

The model is designed to produce projected demographic data for five-year age groups at five-year intervals based on either constant or changing parameter assumptions. The model requires information which is stored in the computer data file for each of the countries. Projections depend on the 1970 data or on the parameters as altered by the user. Basic data are 1970 total population, age composition categorized into 18 five-year intervals, period age specific fertility rates, and a cohort specific mortality rate schedule. The model uses the cohort component method of projection where the 1970 population is projected into the future. All projections start at 1970 and continue by five-year intervals to any time desired by the program user. (Klauff, 1975).

The component method projection procedure used does not include migration and is thus restricted to calculating how many children will be born in the next five-year period and how many people (including children born) will die during the period in each of the age cohorts. The projected population is determined by these two demographic parameters. The model is used in both a combined sex version, where projections are based on the total population, and a two sex version. The combined sex-version simplifies the program algorithms and considerably improves the response time. In the

short run, up to 50 years, the projected population totals using the combined sex model differ only very slightly from the two sex model. Over a longer period differences increase, but considering the flexibility of population growth to changes in the demographic parameters and unknowns such as the marriage function, these differences are considered to be within reasonable bounds.

While the population projection program is the basic model, each of the other POPSOC programs contribute additional parameters and in some cases, submodels. The Economic Development program, for example, utilizes the Cobb-Douglas production function for some of the economic parameters (Handler and Roh, 1975), and the Food program involves a series of reformulations of data based on the United Nations Food and Agriculture Organization.

Detailed User Manuals and Program Commentaries are currently available for the majority of programs. These materials explain how to use the CAI system; provide information on concepts, definitions and the program algorithms; and provide some suggestions as to the practical applications of the program.

The Data

Data is available for over 120 countries. Each country's estimated population in 1970 is used as the base for the projections. No attempt has been made to reconstruct a country's population data and all population data is used as reported by original sources. For the programs which use additional data, attempts were made to obtain the most up to date information from reliable sources. In some cases, the base parameters were developed on the basis of a set of available data. Information on the construction of the parameters is found in each program commentary.

WHAT IS THE PDG/CAI SYSTEM?

In order to describe what is essentially a dynamic medium (visual automated graphs) by means of a static medium (paper and ink) it is best to start with an example. The user interacts with the system through the terminal keyboard which contains specific keys for operational and data request functions. (Figure 1). Each user is provided with a code name to enter the system and also is required to know the PDG program code name. Having entered the system, the user must select one of the programs available in the PDG series. Let us assume the Population Projection Program is chosen. The next step is to select a country to study. The user has the choice of over 120 countries and may select one at a time. At any stage during the operation, the user may return to select a different country.

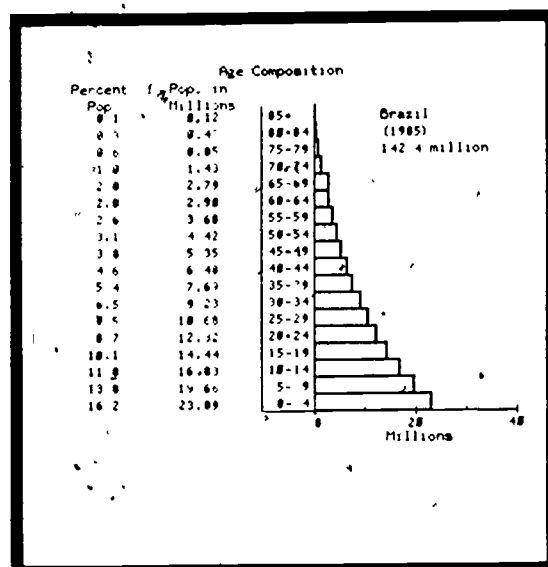
Through a series of requests, each determined on an independent basis, the user may specify the information he requires which is immediately retrieved and shown on the display panel. At each step, directions on how to continue appear on the display panel, and the user makes decisions on how to proceed and gives instructions by typing them in on the keyboard. The details of the Population Projection Program are summarized in the Flowchart in Figure 2, which outlines how to move from one part of the program to the next. Thus a typical operation might be as follows: Project the population of Mexico (point (A) of Flowchart) for 30 years ((D)), changing the Total Fertility Rate gradually from 6.1 children to 3.0 children over the period ((B₂)), but with constant mortality, and plot the number of children 0 - 14 ((D₁)) on a rectilinear graph ((D₂)).

Figure 1

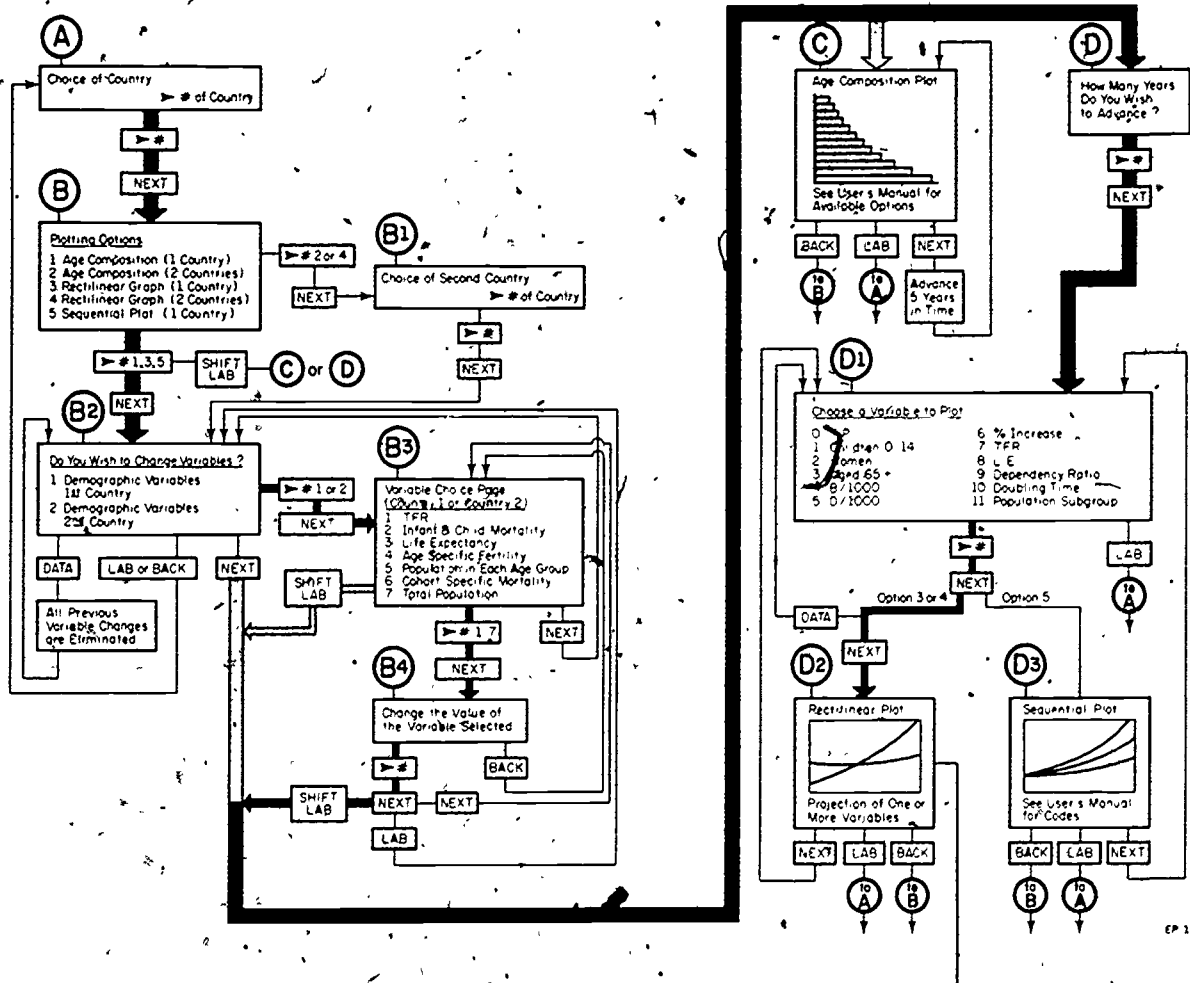


User at PLATO terminal and keyboard.

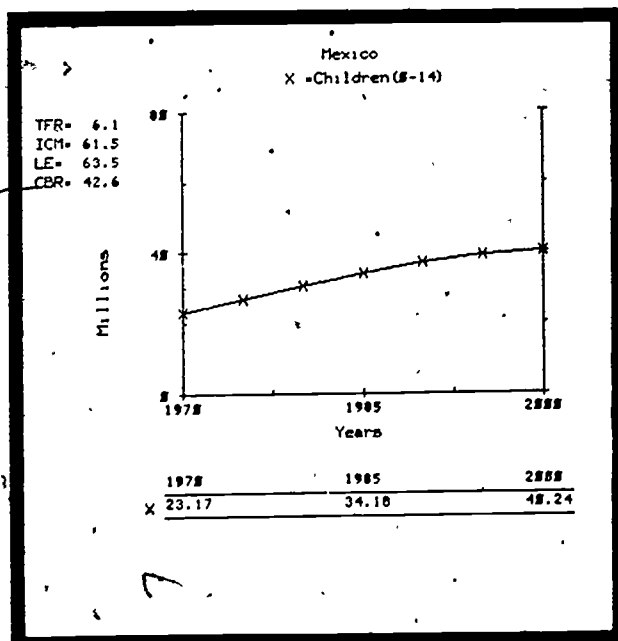
Graphic representation on the display panel is reproduced below.



Population Projections Model: Flowchart



Example of Rectilinear Plot



for the 30 year period. The user will move through the following sections of the Flowchart.

- A choose the country: Mexico
- + B choose the plotting option: rectilinear graph
- + B₂ decision to change a demographic variable
- + B₃ decision to change TFR
- + B₄ change TFR from 6.1 to 3.0 gradually over 30 years
- + D decision to project 30 years
- + D₁ choose indicator #1, children aged 0 - 14, to plot
- + D₂ the above instructions are executed and the graph plotted.

The basic demographic data for 1970 consists of the total population, distribution of the population by five year age-sex cohorts, age specific fertility rates and age specific survival probabilities (obtained from life tables). Based on this information, it is possible to calculate a number of demographic characteristics of a population (at the base year or at any point in the projection). A selected list of the characteristics which are calculated by the computer and may be retrieved for each country is found in Table 2-A. Of these, seven are available as variables which can be changed either immediately or gradually at any point in the projection procedure. (Table 2-B). This enables the user to determine the parameters of the population projection. It also facilitates the changing of base 1970 data should the user feel that this data is inaccurate; should the user want to reconstruct the population of a country at a period prior to 1970; or should the user want to construct a hypothetical country for demonstration purposes.

TABLE 2

A. Demographic Indicators which may be retrieved at any projected year with the bar graph option.

<u>Code Number</u>	<u>Demographic Indicators</u>
0	Total Population in 1970
1	Children (Ages 0-14) (Number and percent)
2	Women (Ages 15-44) (Number and percent)
3	Aged (Ages 65+) (Number and percent)
4	Births per 1000
5	Deaths per 1000
6	Percent Increase per Year
7	Total Fertility Rate
8	Life Expectancy at Birth
9	Dependency Ratio
10	Doubling Time
11	Population Subgroup: From Age ____ to ____ (inclusive)
12	Infant and Child Mortality
13	Distribution of population, in five-year age groups, by percent and in millions
14	Cohort Age Specific Mortality Rate and Period Age Specific Mortality Rate
15	Year of Birth and Mean Age of Death
16	Cohort Age Specific Fertility and Period Age Specific Fertility
17	Mean Age of Childbearing
18	Net Reproduction Rate and Gross Reproduction Rate

B. Demographic Variables which may be changed at various stages in the projection procedure

1. Total Fertility Rate
2. Infant and Child Mortality
3. Life Expectancy at Birth
4. Age Specific Fertility Rates
5. Percent of Population in each Age Group
6. Cohort Age Specific Mortality Rates
7. Total Population
- (8. Crude Birth Rate: Sequential graph only)

Interactive Communication

In the above example, we see the operation of the first basic characteristic of the PDG/CAI system: immediate response interactive communication. The communication between the system and the user is conversational and the limits of the interaction are determined by the user. This enables a great deal of flexibility required for an integrated educational environment. At each step in the procedure (as one moves through the Flowchart) there are an infinite number of choices which can be made. For example, four students working at individual terminals may produce four entirely different projections for a country based on their perceived assumptions of the alternative path of demographic trends.

Value-free Instrument

This leads to the second characteristic of the system. It is value-free in that the decisions on what assumptions to make about the data are determined entirely by the user. For example, proponents of antinatalist or pronatalist views on the future of population growth may construct their arguments without having to alter any elements of the program. In a group discussion situation, the keyboard operator may direct the discussion by demonstrating various options, or on the other hand, the operator may perform an entirely passive function by producing the output requested by the participants. If population education is to educate, not to propagandize or indoctrinate, it must be made possible for students to explore the data through their own biases and values. In this manner, constructive dialogue is a greater possibility.

The Graphic Output

The third characteristic of the PDG/CAI system is the method of graphic output representation. The plasma graphic terminal consists of a matrix grid system which produces a 512 by 512 dot matrix. The major advantage of the plasma display screen used by PLATO is the selectable erase graphic generator. While storage tube devices require bulk erase, this device allows for entering and removing characters from the screen without disturbing other graphics on the screen. Currently there are three graphic output formats available in the majority of POPSOC programs: bar graph, rectilinear graph, and sequential graph. Each of these graphic representations provides effective visual display of the output.

Bar Graph: The bar graph is an age pyramid showing the Age Composition of a population where the size of each five-year age group in the population is displayed. The numbers on the vertical scale in Figure 3 show the inclusive age span that corresponds to each bar on the graph. For instance, "30-34" means people aged 30 through 34 years; and the line beside these numbers in Figure 3 shows approximately 5.8 million people in this age group. Figure 3 represents the combined-sex age pyramid for Brazil in 1975 and also shows four of the demographic characteristics which can be retrieved for each country. By pressing the -NEXT- key the population is projected in five-year intervals or multiples of five, as in Figure 4 (projected to 1985) and Figure 5 (projected to the year 2000). In Figure 4, the projected age distribution for 1985 is chosen for display and in Figure 5, projected sub-group population data are chosen for the year 2000. At any stage in the procedure, by a simple keyboard operation, the user may return to restart the projection at the base year,

Figure 3

Brazilian Age Composition
for the year 1975.

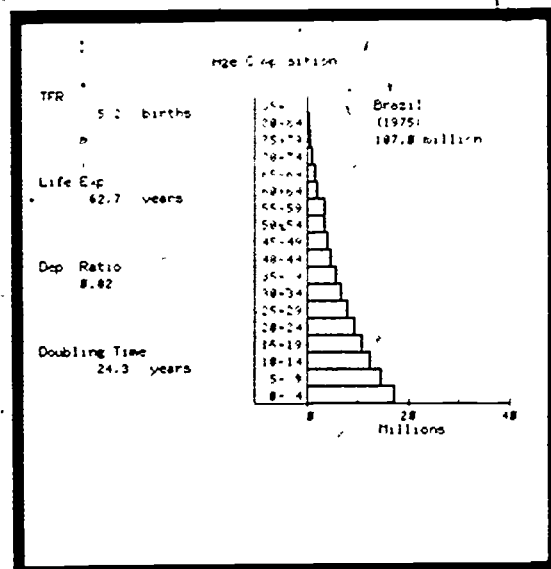


Figure 4

Brazilian Age Composition
projected to the year 1985.

Based on 1970 demographic
parameters.

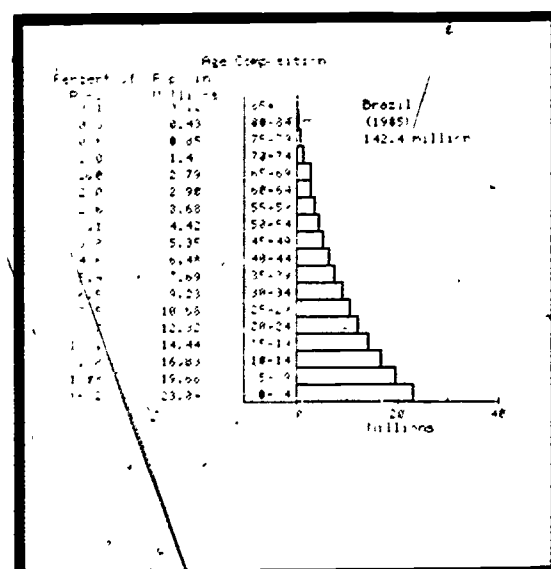
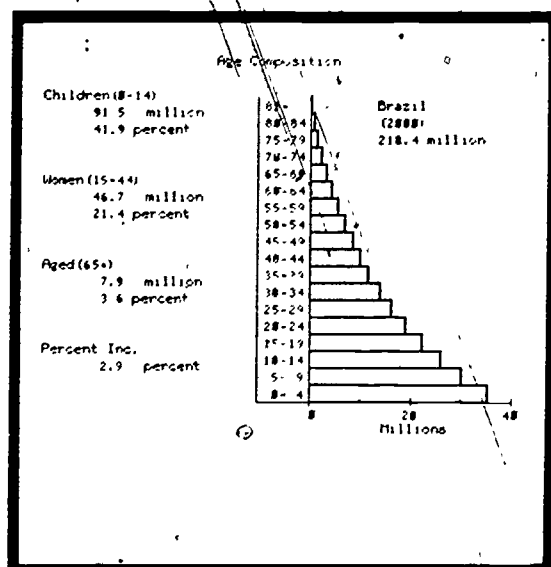


Figure 5

Brazilian Age Composition
projected to the year 2000.

Based on 1970 demographic
parameters.



choose a different indicator to display, select a new graph option or select a new country to work with.

Projecting a population using constant mortality and fertility parameters will eventually result in a stable population with no change in the proportion of population in each age group. Constant mortality and fertility are clearly not realistic conditions in many countries, and in order to make the model flexible and interactive, the program contains a facility to alter these and other parameters either immediately or over an extended period of time.

Figures 6 through 8 introduce two additional features, namely, the ability to change the values of the demographic parameters, either at the base year or gradually, and the ability to compare the age pyramid of a country under differing parameter assumptions. For example, the assumption was made that the Brazilian total fertility rate (TFR) would decline gradually from 5.2 in 1970 to 3.0 in the year 1985, and that life expectancy at birth (LE) would increase to 67 years. Figure 6 shows the age composition projection to the year 1985. (Compare the size of the younger cohorts with those in Figure 4). Now in Figure 7 we have projected to the year 2000, but have assumed a gradual decline in TFR to 3.0 by the year 1985 for Brazil [A], but constant fertility and mortality conditions in Brazil [B]. The projected graph reflects both the differences in the shape of the age pyramids and the difference in cohort and total population size. Although neither of the assumptions may be realistic, the bar graph nevertheless presents the projected demographic consequences of each assumption. Figure 8 illustrates a situation where the fertility and mortality conditions were altered for both Brazil [A] and Brazil [B] -

Figure 6

Brazilian Age Composition projected to the year 1985 with changing demographic parameters.

TFR decreasing gradually from 5.2 to 3.0 over the 15 years.

LE increasing gradually from 62.7 to 67 over the 15 years.

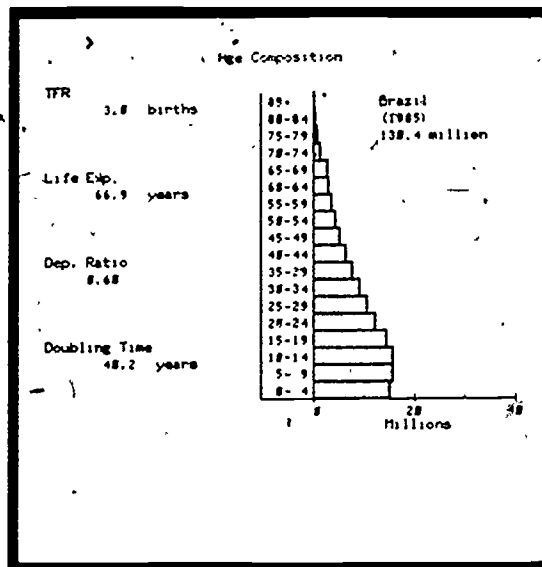


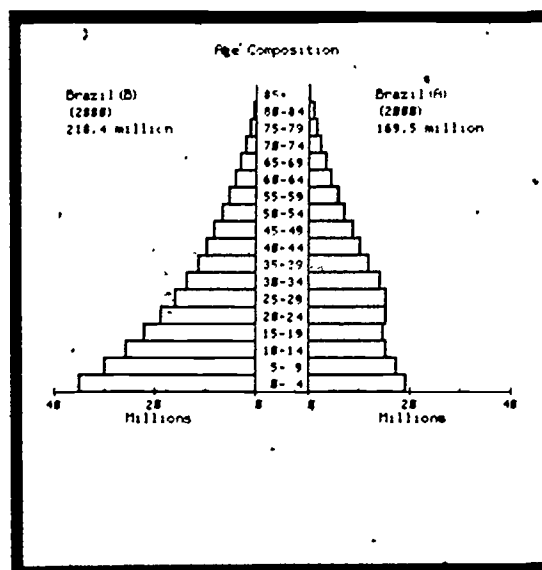
Figure 7

Brazil (A)

Age Composition projected to the year 2000 with changing demographic parameters.

TFR decreasing gradually from 5.2 to 3.0 over the 15 years.

LE increasing gradually from 62.7 to 67 over the 15 years.



Brazil (B)

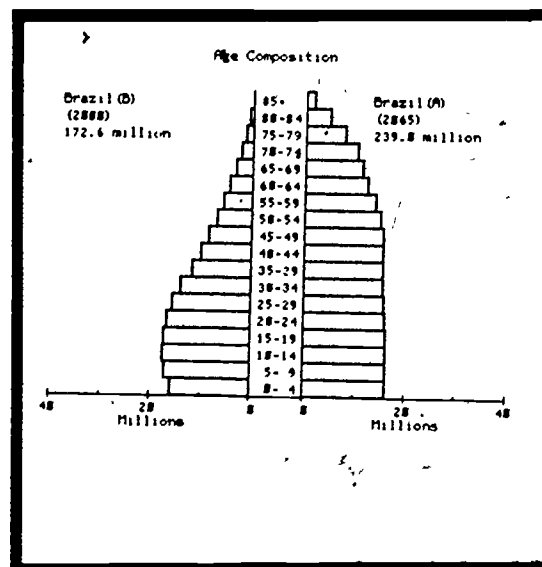
Age Composition projected to the year 2000, based on 1970 demographic parameters.

Figure 8

Brazil (B) Age Composition projected to the year 2000 and Brazil (A) projected to the year 2065, based on changing demographic parameters.

TFR decreasing from 5.2 to 2.1 over 30 years.

LE increasing from 62.7 to 70 over 30 years.



TFR to change gradually to 2.1 and LE to increase gradually to 70 by 2000; this is a rough approximation of replacement level. Brazil [B] is projected to 2000 while Brazil [A] is projected to 2065 which represents the first approximation to a stationary state population. Further iterations deviate only slightly from the total of 239 million people.

The final three bar graphs (Figures 9 through 11) illustrate possibilities of inter-country comparisons with or without variable changes. The estimated 1975 populations for Japan and Brazil are highly similar; yet the shape of the age pyramid reflects the radically different fertility history in each country. (Figure 9). When projected to 2000, the difference becomes even more pronounced (Figure 10). The final bar graph (Figure 11) illustrates the age structure under a condition of declining fertility in Brazil, but constant fertility in Japan.

It is worth mentioning an additional capability of the bar graph option. There are situations where a user may wish to project the population for five years, under either the original or changed parameter assumptions, and then change the parameters again before projecting an additional five years. After having advanced the initial five years (for example, from 1970 to 1975) there is an option which allows the user to alter one or more of the demographic parameters before advancing another five years (from 1975 to 1980). Thus the user may manipulate a projection in five year steps to demonstrate any number of possible growth assumptions. Once a reasonable facility with the system is attained, the average time between selection of a country and the graphing of an age pyramid plot with 100 year projection should take under a minute. Should the user wish to change the fertility and mortality conditions (to those of his choice) and display the projection with the

Figure 9

Japanese and Brazilian Age Composition for the year 1975.

Based on 1970 demographic parameters.

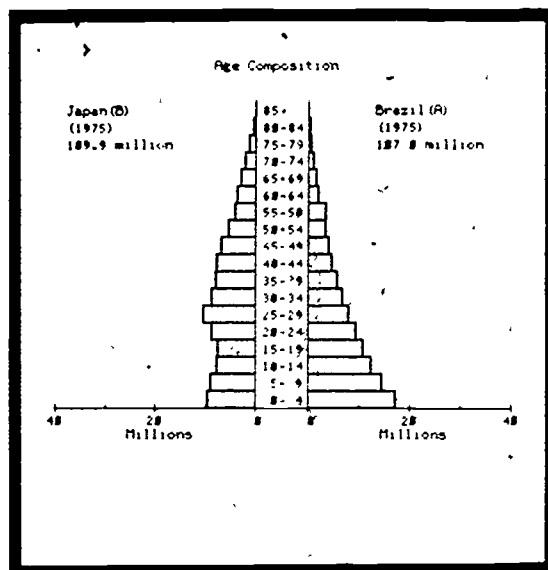


Figure 10

Japanese and Brazilian Age Composition projected to the year 2000.

Based on 1970 demographic parameters.

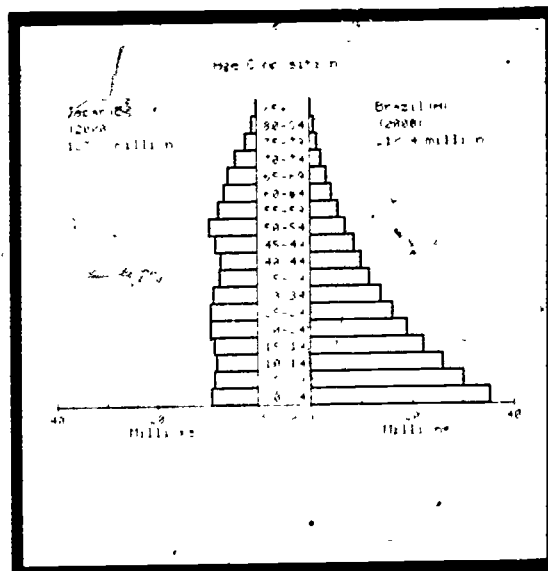


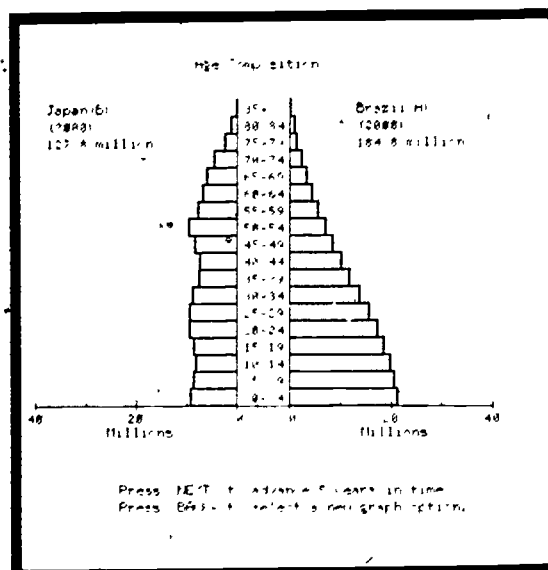
Figure 11

Japanese and Brazilian Age Composition projected to the year 2000.

Japanese projection based on 1970 demographic parameters.
Brazilian Age Composition based on changing demographic parameters.

TFR decreasing from 5.2 to 3.0 over 30 years..

LE increasing from 62.7 to 67 over 30 years.



changed demographic parameters, this might take another 30 seconds.

Rectilinear Graph: Figure 12 is an example of a graphic representation of projected population indicators with time along the horizontal axis and the relevant measure (size, percent, index) on the vertical axis. In the rectilinear and sequential graph options, the user may plot any of the following twelve indicators in 1970 and at any future selected date.

1. Total Population
2. Children (Ages 0-14)
3. Women (Ages 15-44)
4. Aged (Ages 65+)
5. Crude Birth Rate
6. Crude Death Rate
7. Percent Increase per Year
8. Total Fertility Rate
9. Life Expectancy at Birth
10. Dependency Ratio
11. Doubling Time of the Population
12. Selected age groups

In Figure 12 the number of children age 6 to 11 in Brazil and Japan are projected for 30 years under constant fertility and mortality conditions.

An additional option on the rectilinear graph expresses the ratio of the children in Brazil to the children in Japan. In 1970 there were 1.5 Brazilian children (aged 6 - 11) to each Japanese child. By the year 2000 this ratio is projected to increase to 3.3 Brazilian children for each Japanese child. The projected percentage of children age 6 - 11 to the total population in Brazil (Figure 13) is seen to change slightly from 15.6 to 15.8 by the year 2010 (while the same percentage in Japan changes from 9.0 to 8.8). The same projections may be made with variable changes for one or both countries. For example, Figure 14 shows the total population and the children aged 6 to 11 for Brazil, projected for 40 years with TFR changing gradually to

Figure 12

Rectilinear Graph of Children,
aged 6 to 11
projected to the year 2000;
based on 1970 demographic parameters

Plot X = Brazil
O = Japan

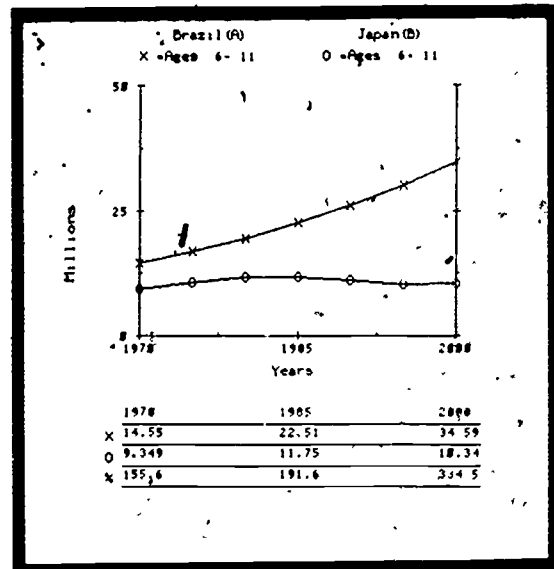


Figure 13

Rectilinear Graph of Brazilian
population and children
aged 6 to 11
projected to the year 2010;
based on 1970 demographic parameters

Plot O = Total Population
X = Children aged 6 to 11
% = Children as percent of
total

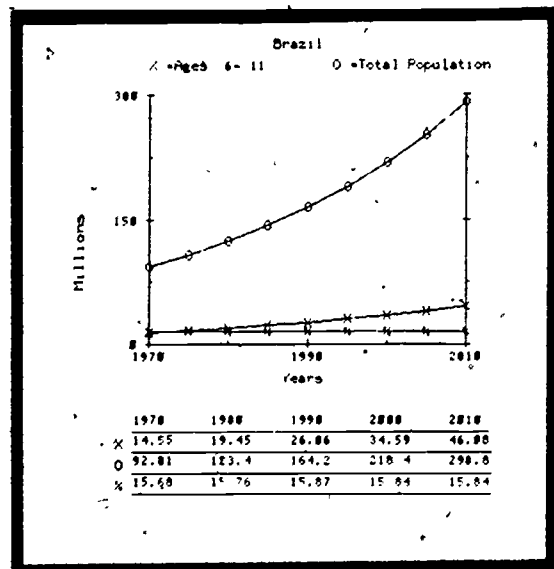
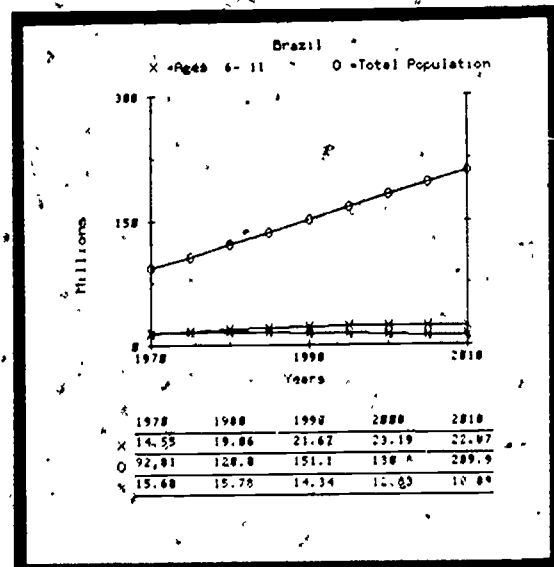


Figure 14

Rectilinear Graph of Brazilian
population and children
aged 6 to 11
projected to the year 2010;
with changing demographic parameters:
TFR decreasing gradually to
2.6 in 30 years
LE increasing gradually to
70 in 30 years

Plot O = Total Population
X = Children aged 6 to 11
% = Children as percent of
total



2.6, and life expectancy at birth changing to 70 by the year 2000. In 1970, sixteen out of every hundred Brazilians fall into the 6 to 11 age group as compared to a projected eleven per hundred in the year 2010, based on the above set of assumptions.

Sequential Graph: This plot option is similar in graphic representation to the rectilinear graph. The same selection of twelve indicators as for the rectilinear graph may be plotted for one country at a time. The unique feature of this graph, however, is the ability to plot multiple projections (up to seven) on the same graph, with each projection representing a different combination of changes in demographic parameters, either immediately, gradually (linear method) or delayed (curvilinear method).

Figure 15 is an example of a sequential plot. Line 0 represents a 40 year projection for the number of children under 15 in Brazil under 1970 demographic conditions. The number of children, in millions, are printed out at selected years. Four parameters are available for change directly without erasing the graph. These are total fertility rate (TFR), infant and child mortality (ICM), expectation of life at birth (LE), and crude birth rate (CBR). Line 1 shows the projection based on the assumption that infant and child mortality decreases from 65.8 per thousand to 26 per thousand over the next 30 years. Line 2 shows the projection where, in addition to the improved mortality assumption, the total fertility rate is seen to decline to 2.6 births per woman by the year 2000. Figure 16 goes through a similar set of operations but this time the graph plots women aged 15-44 years. A large number of projections, with alternative years, parameters changes, or indicators can be made for a country within a short period of time.

Figure 15

Sequential Graph of
Brazilian children
aged 0 to 14
projected to the year
2010;
under three sets of
demographic assumptions

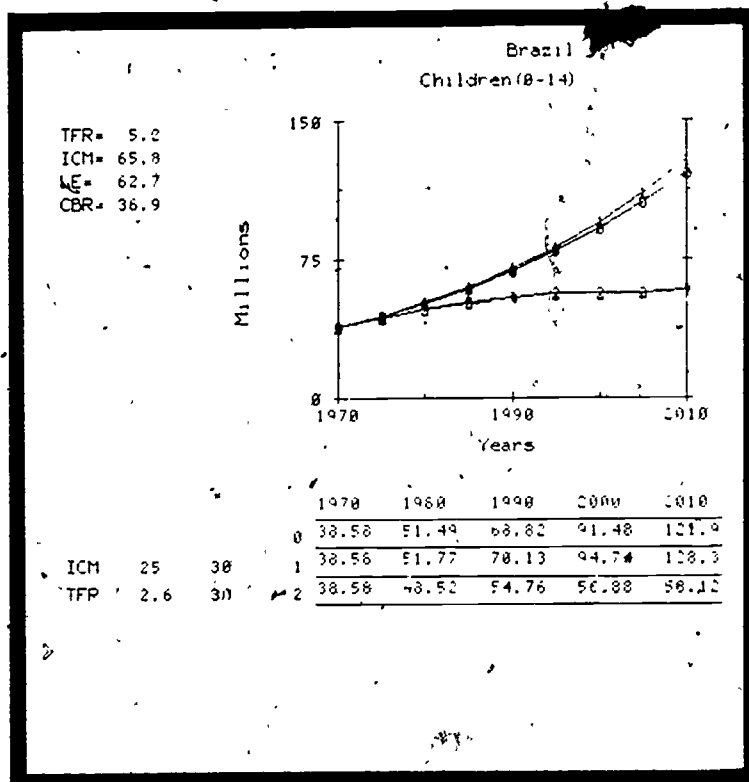
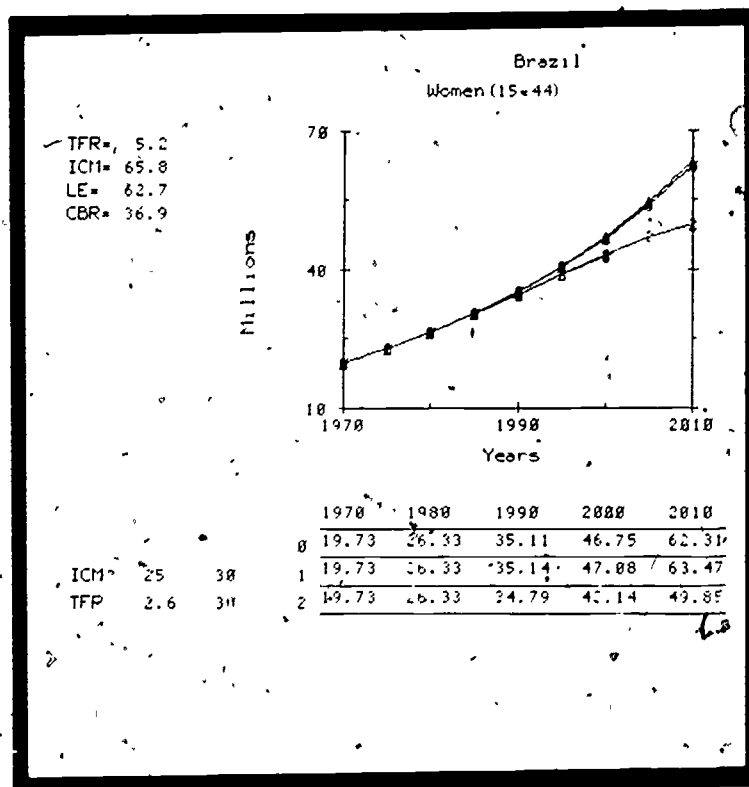


Figure 16

Sequential Graph of
Brazilian women
aged 15 to 44
projected to the year
2010;
under three sets of
demographic parameter
assumptions



POTENTIAL USES OF THE PDG/CAI SYSTEM

It is not possible in the context of this paper to discuss the details of all the programs nor to describe all the applications. Rather an attempt is made to outline some examples of the potential uses of the program in the various areas of population education.

The system can be used in individual or group sessions to demonstrate the consequences of population growth. It is currently being used in Washington, D.C. at the State Department, in the offices of the Agency for International Development (AID), and at a number of universities throughout the country. Regular population awareness sessions are conducted for students, government officials, foreign nationals and other interested individuals in a framework of constant interaction between the computer and the participants.

As an instructional resource the range of possible uses of the system is vast. Due to the graphic nature of the output and the flexibility of the program design, the PDG/CAI systems may be used at different educational levels. The degree of complexity may be determined by interaction between the demonstrator (user) and the audience (participants) in the activity. The programs have been successfully used with school children of all ages, university students, community groups, government officials and professionals in the field of population. Currently there are three ways in which the output may be utilized as an instructional resource:

1. Actual demonstrations of certain topics, principles, etc. with the students either passive or participating in the discussion. The instructor, or someone assigned to conducting the demonstrations

may both pose questions and answer student questions with immediate response on the display screen. Students may be presented with problems, issues or topics which they will then complete through individual interaction with PLATO. The programs are simple to operate, allowing each user to manipulate and interact with the system on an individualized basis.

2. A lecturer may use the system to prepare a set of slides on a specific topic for presentation to his class, or to a larger audience. The taking of the slides is extremely easy and the only delay would be in the developing. This tends to provide for greater structure and yet allows the instructor to experiment with the data. The instructor is not tied to available visual material and can produce graphic output for the ideas, concepts, data, etc. that may be used in the teaching process.
3. Hard copy facilities are available which will allow an instructor to retain any of the infinite graphic outputs to hand out to his class. This can be done on the day of the lecture and requires only minutes to prepare. For example, the figures in this paper are reproductions of PLATO varian print output.

PRACTICAL APPLICATIONS

In order to convey a sense of the ways in which an educator in the field of population education can utilize the system, three examples have been prepared. The examples focus on the concepts themselves, rather than on the method of communication of the concepts. For example, it is possible

to explain zero population growth to school children and to graduate students in demography with the same material, but with different degrees of complexity.

Example # 1: Population Projection

The most obvious use of the system is to demonstrate the demographic consequences of population growth. Attempts at estimating the future size of a population are by no means new. (United Nations, 1973; Shyrock, et al., 1971). The history of population projection includes early attempts by King, Perry, and Graunt in the 17th century to estimate future population size based on knowledge of total population. (United Nations, 1973: 558-561). Projection techniques seek to use current knowledge to evaluate the effects of mortality, fertility, and migration parameters on the population size and structure of a country. The extent to which projections of population growth approximate reality depends very much on either the continuation of current demographic trends or the correct evaluation of the direction of change in the components of the demographic equation. The basic usefulness of a population simulation projection model, therefore, lies not in its predictive value, but rather in its ability to demonstrate alternative paths under the constant or dynamic assumptions of the model.

A number of models of computer-simulated population projections have been produced in recent years to deal with specific aspects of population growth. Keyfitz and Flieger (1971) dealt with the theory and methodology involved in the computation of population projections. They calculated basic demographic information for a large number of countries. Frejka (1973) utilized the techniques of population projection to identify the demographic trends necessary to reach a non-growing stationary state.

Van de Walle and Knodel (1970) and Pick (1974) have presented computer simulation programs for use as teaching devices in demography. Models designed by Hyrenius (1965) and the Tempo group (1974) are examples of work designed to demonstrate and analyze demographic and socio-economic interrelations. Bogue and Rehling (1974) and Shorter (1974) have produced detailed manuals of techniques for making population projections, the former emphasizing how to make age-sex projections by computer and the latter focusing on the use of projections in development planning.

The PDG program may be seen as a contribution to this list of educational resources available for the field of population education. The added contribution appears to be, first, its ability to display the concepts and data of population by means of visual graphics, and second, the interactive conversational properties of the system. The following example suggests a possible use of the population projection program.

Using various combinations of fertility and mortality in the projection procedure, it is possible to select a future population goal and compute the alternative paths (projection variants) which achieve this desired goal. This is what Frejka does in his book, The Future of Population Growth (1973). Figure 17 is an example of a sequential graph, plotting alternative paths to a stationary world population in the year 2070, based on assumptions similar to those suggested by Frejka.

It is possible on the keyboard to alter the parameters to simulate conditions under which a stationary state population can be achieved. Figure 18, for example, represents the result of an assumption that population replacement level is reached for Mexico and France (two countries with 1970 populations of approximately 50 million) by the year 2000 and zero population

Figure 17

Sequential graph of World Total Population, projected to the year 2070. Base 1970 parameter: projection (0), changing demographic parameters in two alternative paths to stationary population (1 and 2).

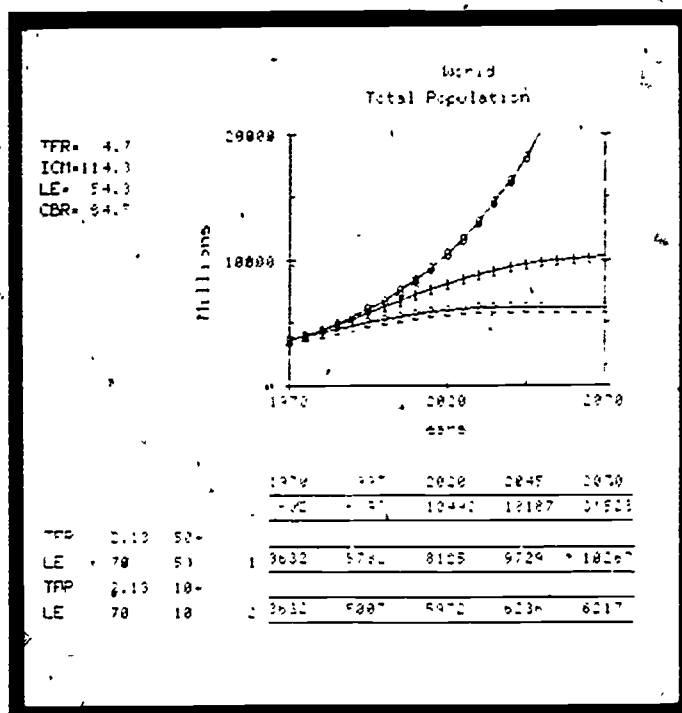
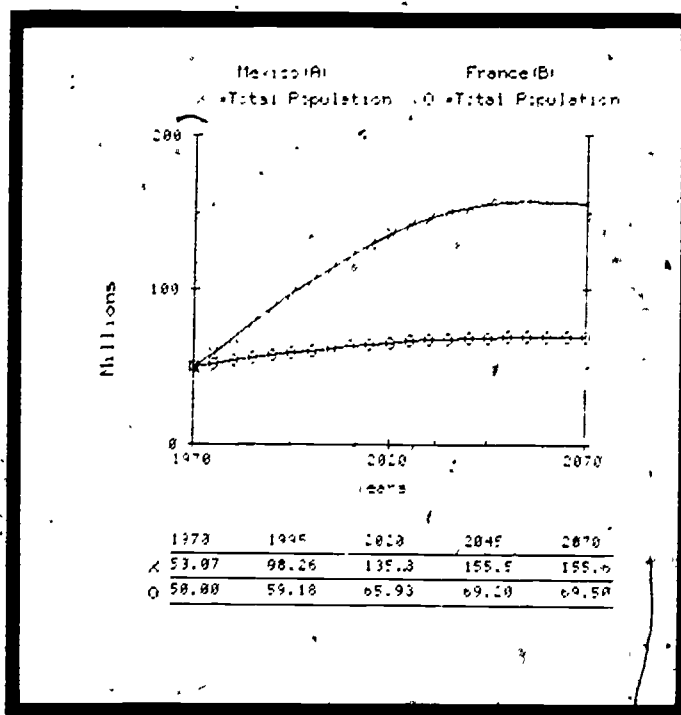


Figure 18

Rectilinear graph of Total Population of Mexico and France projected to the year 2070, with changing demographic parameters.

TFR decreasing gradually to 2.1 over 30 years (both Mexico and France)

LE increasing gradually to 71 in 30 years (for Mexico) and remaining constant at 71 (for France).



growth by about the year 2060. The combination of fertility and mortality conditions which produce a new reproduction rate of 1.0 are provided by the computer and can be explained through various keyboard operations. The total fertility rate for both countries is projected to decrease gradually to 2.11 in 30 years and the Mexican life expectancy is projected to increase in the same period to 71, equalling the French life expectancy. Advancing the population in five-year intervals, by the middle of the 21st century, the Mexican population becomes stationary at around 160 million and the French population becomes stationary at about 70 million. It should be remembered that the data presented are simulated. Nevertheless, the calculation presents an alternative path to achieving a stationary population by the mid 21st century and suggests what the population size might look like.

It is also possible to view the demographic consequences of current rates of population growth for a country and to suggest alternative population policy strategies in the framework of a simulation exercise. Such questions may be asked as: --What is the current size of the labor force and what is the dependency ratio? --What will the size of the labor force be in 30 years' time if fertility rates decline gradually over the period and how will the dependency ratio be affected? --How many primary school age children will there be in the year 1980?

Example # 2: Age Structure

Much can be learned about the past and the future of a country from an examination of its age structure or age composition. Knowledge of the composition of a country and the constant or changing pattern of the age structure has important implications for understanding social institutions

within the society. Using the bar graph option, the following are some of the many questions which may be posed.

What does the age composition of a country look like?

How is the age structure of a population formed?

What will the age structure look like under constant mortality and fertility -- the stable population situation?

How does the shape of the age structure differ under the following conditions?

High Mortality and High Fertility

Low Mortality and High Fertility

Low Mortality and Low Fertility

What can you tell about the demographic history of a country from the shape of its age pyramid? For example, the 1970 population of France, Russia, USA, Mexico.

How does a population age or grow younger?

What are the social consequences of changes in the age structure of a country?

What is the contribution of the age composition to the growth rate of the population?

To illustrate the use of the system in answering the above type of question, let us examine the question of the effect of fertility and mortality on the ageing of a population, an issue which has been given increasing attention in the United States. (Population Reference Bureau, Vol. 30, No. 3). The example has been used in an undergraduate population course as part of a series of PLATO exercises carried out by the students. The exercises were designed to enable students to test various assumptions about the impact of mortality and fertility on age structure and to suggest the possible implications of change for specific countries.

The fertility and mortality schedules of a population determine its age structure. In a closed population (no migration), it can be shown that

any combination of fertility and mortality will (in the long run) give rise to a population whose age structure is stable -- one in which the percentage of the total population in any given age group will not vary provided that fertility and mortality rates do not alter. Although it is, the combination of fertility and mortality characteristics which determines the age structure of a population, the exercise attempts to demonstrate that fertility is of much greater relative weight than mortality. The object is to illustrate that birth rates and, not death rates are the major determining factor of changes in age structure. The ageing of a population, as has occurred in developed countries, may be attributed primarily to declining fertility rather than declining mortality. (Coale, 1956; Coale, 1964; Keyfitz, 1971).

Consider a population where high birth rates and death rates have existed for some time. The Ivory Coast is an example of such a country, with a total fertility rate in 1970 of 6.9 and life expectancy at birth equal to 43 years. The age structure is shown in Figure 19. The proportion of the population in the 65+ age category is presented on the plot. Two sets of assumptions are made about the path of future population growth for the country: one set referring to Population A and the other to Population B.

The assumption is made that the population moves in the direction of a stable and stationary state, where the number of births and deaths are equal and where any past irregularities of fertility and mortality are no longer reflected in the age structure. For Population A this is achieved by the following operations:

Figure 19

Ivory Coast Age Composition
for the year 1970.

2.7 percent of the population are aged 65 and over.

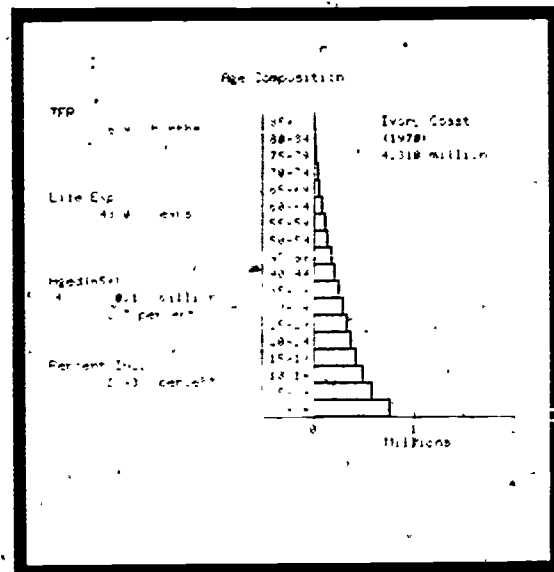


Figure 20

Population A Age Composition
Ivory Coast (A) projected to
the year 2070 (Stationary
Population).

Ivory Coast (B) projected to
the year 2000 (Replacement
level).

TFR decreasing gradually
from 6.9 to 3.26 over 30
years.

LE constant at 43.0.

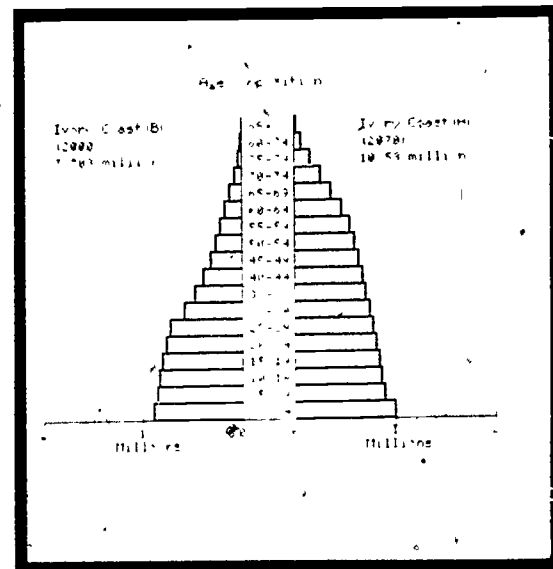


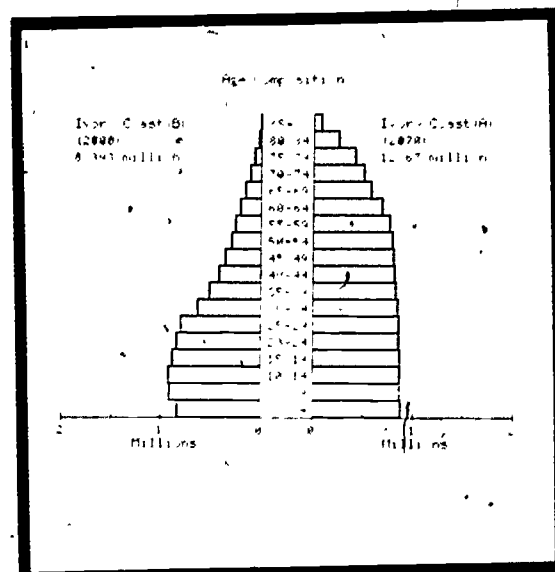
Figure 21

Population B Age Composition
Ivory Coast (A) projected to
the year 2070 (Stationary
Population).

Ivory Coast (B) projected to
the year 2000 (Replacement
level).

TFR decreasing gradually
from 6.9 to 2.14 over 30
years.

LE increasing gradually
from 43 to 70 over 30 years.



-- Change the TFR from 6.90 to 3.26 over 30 years.

The combination of these operations produces a net reproduction rate of 1.0 (replacement level) by the year 2000. The population is then projected to the year 2070 which is an approximation to the stationary population with a zero population growth and high mortality and fertility conditions. The replacement level age composition and the stationary state age composition are shown in Figure 20. For Population B the zero population growth is achieved by the following changes in parameters:

-- Change the TFR from 6.9 to 2.14 over 30 years.

-- Change the LE from 43 years to 70 over 30 years.

The population projected to the year 2070 will thus be an approximation to a stationary population with a zero population growth, and low fertility and mortality rates. The replacement level and stationary state age composition are shown in Figure 21. Note the following age structure data of both populations in the year 2070, obtained from options 1, 3 and 11 on the bar graph (see Table 2).

Age Category	Percent of Population in each Age Category	
	Population A High Fe, High Mo (2070)	Population B Low Fe, Low Mo (2070)
0-14	26.3	20.8
15-64	65.3	64.6
65+	8.4	14.6

Note: Fe = Fertility, Mo = Mortality

In Population A (2070) with high fertility and high mortality, 8.4% of the population are aged 65+ and in Population B, with low fertility and low mortality, 14.6% of the population are aged 65+. It is clear that as both fertility and mortality conditions have changed -- TFR decreasing and LE increasing -- the population has aged with the proportion of the population in the 65+ group having increased considerably.

Figure 22 contrasts the age structure of the two populations and Figures 23 and 24 illustrate the passage of growth of the 65+ age category over the 100 year period for both populations.

But we are left with an important problem. In the transition from high to low fertility and mortality rates, it cannot be concluded whether the change in age structure (ageing) is attributable to one of these factors or to both.

To overcome this problem, we construct a third population (Population C) with high fertility and low mortality. To construct Population C, the following operations are applied to the original 1970 Ivory Coast population:

- TFR changed from 6.9 to 3.26 over 30 years. This is the TFR of Population A.
- LE changed from 43 to 70 over 30 years. This is the LE of Population B.

Population C is projected 100 years by which time the population has become stable with constant high fertility and constant low mortality, but with a rapidly growing population, (Figure 25). Note that while the total population and the numbers in each age category increase, the proportion of the total population contained in each age category will remain unchanged. The following is a summary of the Age Structure of the three populations in the year 2070.

Age Category	Percent of Population in each Age Category		
	Population A High Fe, High Mo	Population B Low Fe, Low Mo	Population C High Fe, Low Mo
0-14	26.3	20.8	31.3
15-64	65.3	64.8	60.8
65+	8.4	14.6	7.9

We are now able to illustrate the influence of fertility and mortality on the ageing of a population.

Influence of a change in mortality on age structure: Compare the simulated age structure of population A (High fertility - High mortality) with population C (High fertility - Low mortality) in Figure 26. The comparison illustrates that with lowered mortality and constant fertility, the proportion of person aged 65+ is 7.9 as against 8.4% for population A. It would appear then that a non-growing stable population with high mortality has a very similar process of ageing to a growing stable population with low mortality, provided fertility levels are similar and constant. While this is a hypothetical ideal type example, students are encouraged to find and compare actual countries where the above patterns are evident, in situations where populations are neither stable nor stationary.

Influence of a change in fertility on age structure: Compare the age structure of population B (Low fertility - Low mortality) with population C (High fertility - Low fertility) in Figure 27. The comparison illustrates that with lowered fertility, and constant mortality, the proportion of persons aged 65+ is 14.6%. (Where the percentage changes from 8.4% to 14.6%).

Figure 22

Age Composition for Population A (2070) and Population B (2070)

Population A (Ivory Coast (A))

TFR $\rightarrow 3.26 \rightarrow 30$

LE constant at 43

Percent of population 65+ =

8.4%

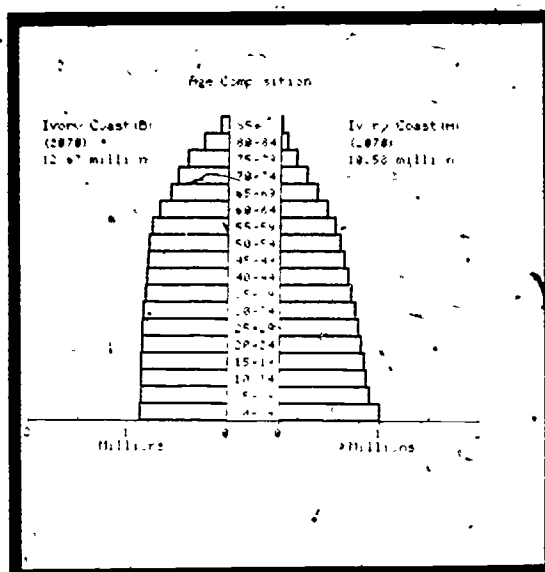


Figure 23

Rectilinear graph of Population A data projected to the year 2070

TFR $\rightarrow 3.26 \rightarrow 30$

LE constant at 43

Plot 0 = Total Population

X = Population aged 65+

% = 65+ as percent of total

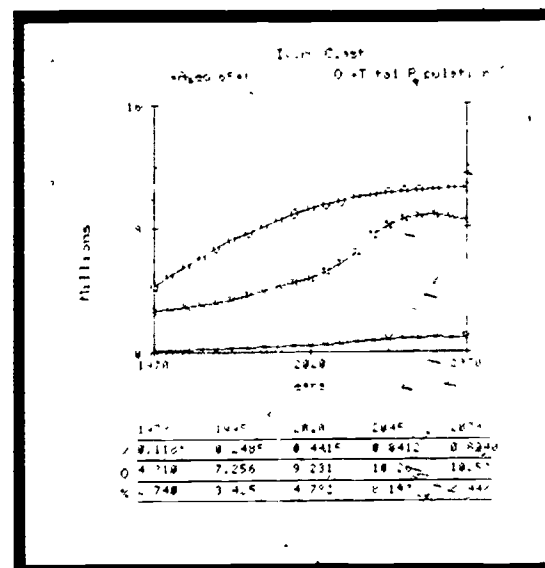


Figure 24

Rectilinear graph of population B data projected to the year 2070

TFR $\rightarrow 2.14 \rightarrow 30$

LE $\rightarrow 70 \rightarrow 30$

Plot 0 = Total Population

X = Population aged 65+

% = 65+ as percent of total

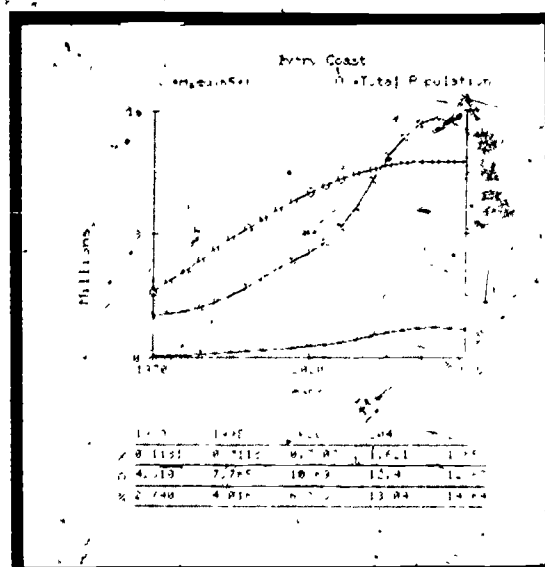


Figure 25

Population C Age Composition
Ivory Coast projected to the
year 2070 (stable population)
TFR decreasing gradually
from 6.9 to 3.26 over 30
years
LE increasing gradually
from 43 to 70 over 30 years

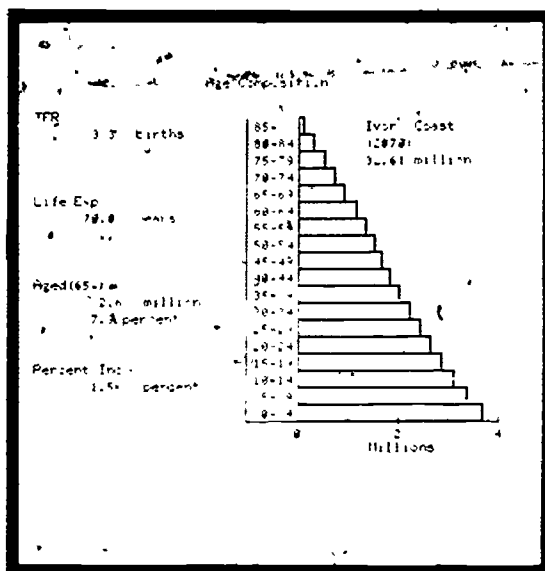


Figure 26

Age Composition for Population A
(2070) and Population C (2070)
Population A (Ivory Coast (B))
TFR $\rightarrow 3.26 \rightarrow 30$
LE constant at 43
Percent of population 65+ =
8.4%
Population C (Ivory Coast (A))
TFR $\rightarrow 3.26 \rightarrow 30$
LE $\rightarrow 70 \rightarrow 30$
Percent of population 65+ =
7.9%

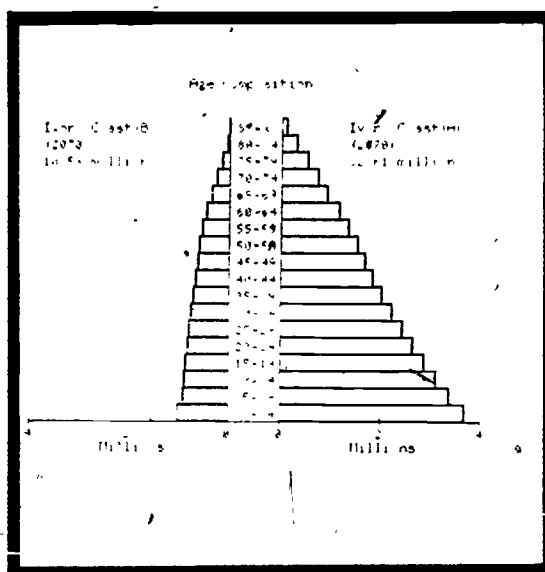
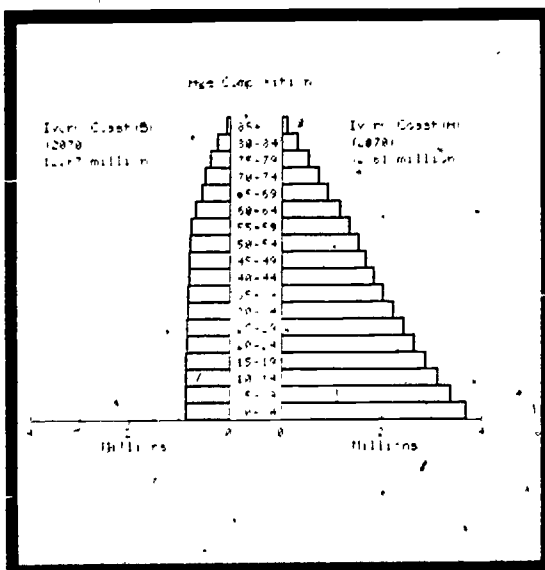


Figure 27

Age Composition for Population B
(2070) and Population C
Population B (Ivory Coast (B))
TFR $\rightarrow 2.14 \rightarrow 30$
LE $\rightarrow 70 \rightarrow 30$
Percent of population 65+ =
14.6%
Population C (Ivory Coast (A))
TFR $\rightarrow 3.26 \rightarrow 30$
LE $\rightarrow 70 \rightarrow 30$
Percent of population 65+ =
7.9%



It can be seen graphically that a change in fertility has a considerable impact on the shape of the age structure. This has been a somewhat lengthy example of the way in which the population projection program can be used in demonstrating demographic concepts. The above example may be demonstrated at the terminal or a lecture using slides or hardcopy can be prepared for presentation in a classroom setting. The students may then reproduce the same situation on their own or may investigate a different set of countries as part of a project.

Example # 3: Population Education and Population Policy: The Case of Brazil

Finally, an example is presented which suggests the manner in which population education can contribute to a better understanding of population policy. The PDG/CAI system is viewed as a useful tool in aiding in the understanding of demographic and social structural consequences of population growth. This example makes use of the Educational Costs and Enrollment program, in addition to the Population Projection program.

The following problem may be developed in a class or seminar group environment. Brazil, the largest country in Latin America and the seventh largest in the world, had a population of 92.8 million in 1970 and has been growing at the rate of 2.8 percent per year, resulting in a population doubling time of 24 years. (Population Bulletin, 1969: 98-115). The very general question raised is whether Brazil, a country with a largely unpopulated hinterland with vast natural resources, may derive benefits from efforts to lower the rate of population growth or whether the country can optimally accommodate the projected population increase.

A United Nations report to the World Population Conference in Bucharest states that: "The historical experience, combined with our understanding

of population trends as affected by economic and social change, suggests that, as modernization proceeds, populations undergo a demographic evolution which slows down their growth significantly". (United Nations, 1974). But an analysis by Gendell (1967) of fertility and development in Brazil for the 1940-60 period concluded that a decline in fertility did not necessarily follow from changes in economic development. There are, in fact, a range of views which exist concerning the relationship between population growth and economic growth and development. On the one hand, there is the opinion that economic growth and improvements in social conditions are impossible under rapid population growth conditions, while at the opposite extreme, it is suggested that rapid population growth will contribute to economic and social well-being. (Zaidan, 1969; Robinson and Horlacher, 1971; Kuznets, 1967).

According to a Brazilian economist, Vaz da Costa, the rapid population growth is one cause of acute problems in employment, education and economic development in Brazil (Vaz da Costa, 1969), and additional information on the Brazilian social and economic structure corroborates this conclusion. (World Bank, 1974: 23-43). The official policy of Brazil, however, "on the one hand, is committed to a pronatalist position, but, on the other hand, feels responsible to provide family planning services as a human right". (Nortman and Hofstatter, 1974). And the official statement of the Brazilian delegation to the Bucharest conference noted that "Available data indicates that Brazil will be able to absorb the foreseeable demographic increments and further, that this growth is even to be considered as a necessary element for economic development, for national security and for the integration of vast empty stretches of

national territory into national product". (Almeida, 1974). This brief background to the population-economic development policy controversy in Brazil suggests the need for, and usefulness of, information on which alternative strategies or options for decision making can be based. The PDG simulation program allows the user (policy maker) to be an interactive participant while reviewing alternative strategies in a highly personal and perceptually optimal framework. L

Evidence exists to indicate that planners in developing countries are generally dissatisfied with population policies generated by "outside" consultants on the basis of "imported" models of growth. (National Academy of Sciences, 1974: 75). There is also evidence that the strong inbuilt emphasis on family planning services in foreign aid programs for Brazil has been subject to bitter criticism, regardless of the effectiveness of the programs. (Stycos, 1971; Daly, 1970). The differential perception of what constitutes a population problem for a country, and how this perception relates to the planning of solutions, suggests that the "local" policymaker should be involved in the definition of the problem before being expected to participate enthusiastically in the implementation of population influencing and population responsive policy decisions. The population educator's responsibility, therefore, consists of communicating population concerns, rather than population solutions, and helping to demonstrate the determinants and consequences of alternative rates of population growth in specific contexts. This is not to say that a demographer should not be involved in social engineering, but rather to stress that a distinction should be made between population education and population policy. Population influencing policies involve

knowledge of the causes of growth -- the components of the demographic equation, while population responsive policies involve knowledge of the consequences of growth -- educational facility requirements, dependency ratios, labor force conditions, food and energy demand, urbanization, etc.

Once the context of the problem has been outlined, here follows an example of how the PDG/CAI system may be used to contribute to the merger of population education and population policy. The students are presented with the above information and it is suggested that after some basic reading and group discussion that they place themselves in the position of an official concerned with the demographic and socioeconomic consequences of population growth. The exercise can then be conducted in a group session or each student may produce a position paper on a specific topic. This is a particularly useful exercise in an attempt to discuss social indicators and the development of population policy. The example outlined here will be used in the Fall semester 1975 in an undergraduate sociology course at the University of Illinois. Each student will analyze aspects of the socioeconomic consequences of population growth in a selected country.

In order to limit the scope of the example, let us consider a series of hypothetical questions posed by an official in the Brazilian Education Ministry. First, such an official might be interested in the determinants of population growth.

What are the current demographic characteristics of Brazil and more specifically, what does the age composition look like?

The official, with very little previous demographic or mathematical experience, could then produce a series of graphs similar to Figure 3 (page 15).

What would happen to the age composition of Brazil under constant growth parameters and under changing fertility and mortality conditions?

Graphs similar to Figures 4 through 8 (pages 15 and 17) are examples of various alternatives which might be presented based on the official's choice of parameter changes and projection period.

How does the age composition of Brazil compare with a developed country of similar population size, for example, Japan; and what would these distributions look like in 25 years?

Figures 9, 10 and 11 (page 19) compare the Brazilian and Japanese age structure. The 1975 Brazilian age structure is typical of countries with a high rate of fertility, while the Japanese pattern, besides having a truncated tail typical of countries with a recent history of fertility reduction, can be seen to have additional irregularities.

What is the likely impact on population growth of an increase in life expectancy at birth to 70 years, achieved by 1990 with constant fertility over the period; a decline in TFR to 2.6 by 1990 with constant mortality, and what is the likely combined effect?

This question suggests one of many possible growth patterns of the Brazilian population. In Figure 28, line 0 represents the base 1970 projection, line 1 the LE change projection, line 2 the TFR change projection and line 3 the combined projection. With no changes in fertility and mortality, the projected population will be 164 million in 1990 and 291 million in 2010. The improved mortality conditions (line 1) would add approximately 5 million in twenty years and 24 million in forty years. The decrease in fertility (line 2) would have a much greater impact by controlling growth to

Figure 28

Sequential graph of total population for Brazil, projected to the year 2010. Base (1970 parameter) projection and three projections with changing demographic parameters.

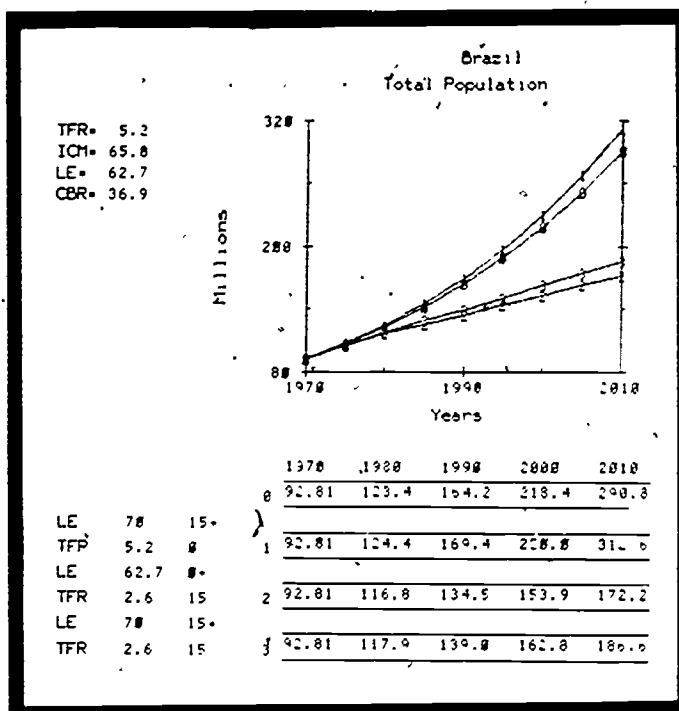
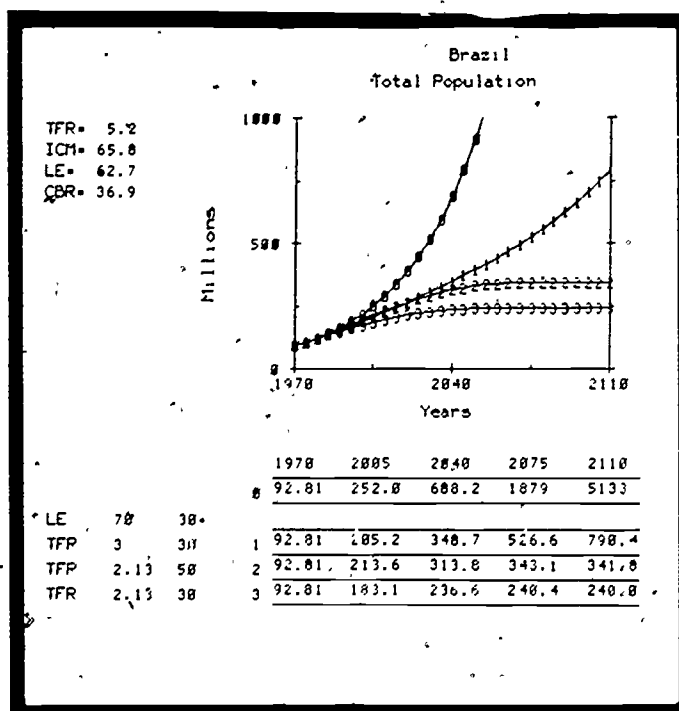


Figure 29

Sequential graph of total population for Brazil projected to the year 2110. Base (1970 parameter) projection (0), three child family (1), and two alternative paths to stationary population. (2 and 3)



30 million less than the base projection in 1990, and 119 million less in 2010. The combined effect is plotted in line 3 of Figure 28.

Finally, the official might be interested in choosing a population projection objective, such as a stationary population to be achieved in about 100 years as compared to a three-child family population in the same period with LE improving to 70 years. The alternatives are limitless, and Figure 29 illustrates one of the alternative projections implemented to provide an answer. Line 0 is the base projection, line 1 is based on an increase in LE to 70 and a decrease in TFR to 3.0 in 30 years; line 2 is based on an increase in LE to 70 in 30 years and a decrease in TFR to 2.1 in 50 years; and line 3 is based on a similar mortality change, but fertility reaching a constant of 2.1 in 30 years, not 50 years.

Once the basic determinants of population growth are understood, it is possible to devise population influencing policies aimed at either demographic or social structural responses to the growth. It should be noted that no attempt was made in this paper to evaluate the simulation projections which are in themselves neutral. The Brazilian response to the graphic output may invoke sentiments suggestive of no defined policy, the encouragement of early marriage, restriction of commercial sale of contraceptive devices and legal abortion, and other methods of fertility encouragement, by those who consider a rapid rate of growth to be beneficial to national development. On the other hand, however, the projections might suggest to advocates of restricted growth that family planning programs, delayed marriage and other means of fertility reduction should be implemented. The point to be made is that the interactive capacity of the system enables the user to test and re-evaluate the implications of pre-

conceived notions. It may also facilitate a meaningful dialogue between advocates of opposing points of views by demonstrating the nature and extent of population growth.

Based on knowledge of the determinants of population growth, population responsive policies can be discussed by examining the consequences of population growth for the social, political, economic, and ecological structures of a country. Returning to the interests of the Education Ministry, one of the consequences of a high rate of population growth is the necessity to absorb larger cohorts of children into the educational system each year. It is estimated that in 1970 there were 14.6 million children (Figure 12) aged six to eleven in Brazil (15.7 percent of the total population), and that 76 percent of these children were attending school, amounting to 10.9 million primary school children (Figure 30). By the year 2010 with constant fertility and mortality conditions, the number of children 6 to 11 is projected to 46.1 million, with 34.8 million expected to attend school under current enrollment rates (Figure 30, line 0). If the assumption is made that enrollment rates will improve, and a reasonable estimate might be a gradual increase to a 90 percent enrollment rate by the year 2010, the number of students will increase to 41.5 million (Figure 30, line 1). Should the official require some information on the number of primary students under changing demographic parameters (declining fertility -- TFR from 5.2 down to 2.6 gradually over 30 years and LE from 62.7 up to 70 gradually over 30 years), these projections may be included. Line 2 (Figure 30) shows the number of students with new demographic conditions, but current enrollment rates; and line 3 shows the number of students with the new demographic and enrollment conditions.

Figure 30

Sequential graph of primary students for Brazil projected to the year 2010. Base (1970 parameter) projection and three projections based on changing demographic and educational enrollment parameters.

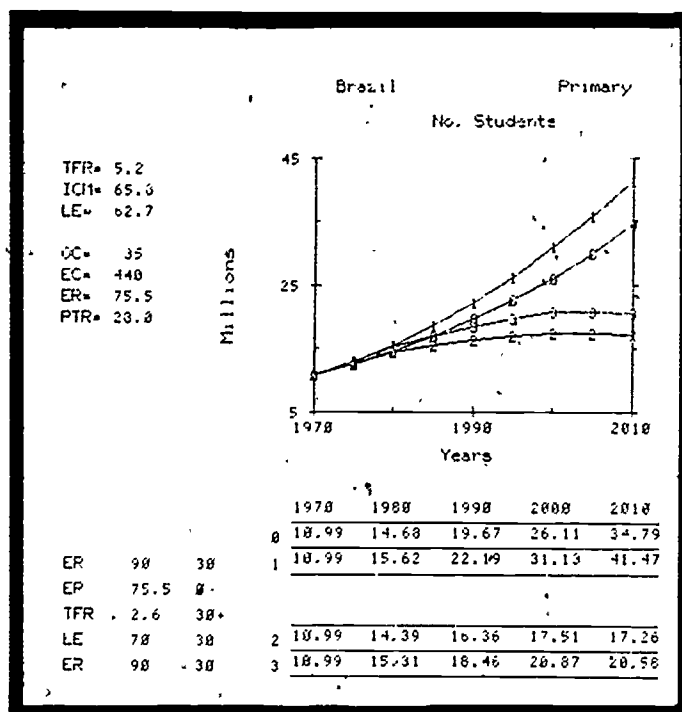
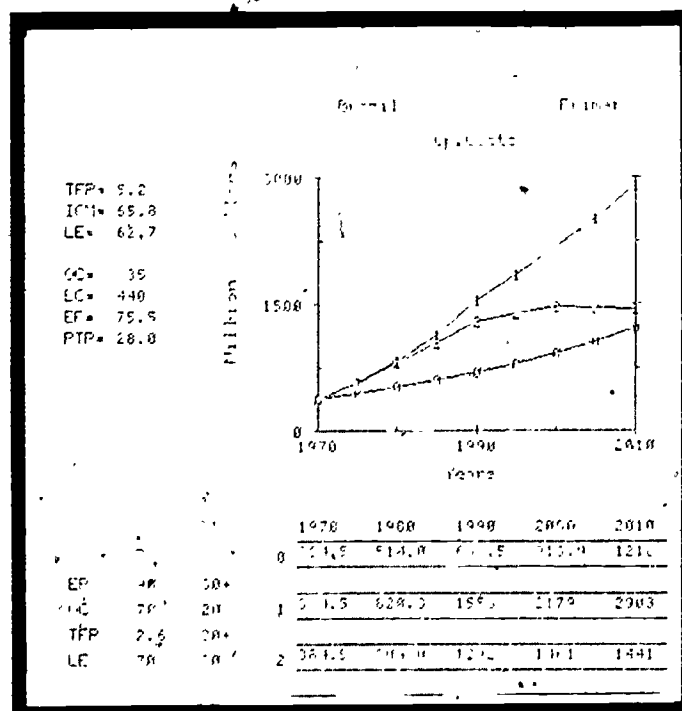


Figure 31

Sequential graph of primary education annual operating costs for Brazil projected to the year 2010. Base (1970 parameter) projection (0), projection based on changing education parameters (1), and projection based on changing education as well as demographic parameters (2).



With the PDG education program, it is possible to link educational costs to the projected student population. Assuming that the Education Ministry expects to have a limited budget for both expansion and operating costs in the coming years, the following analysis might be of interest. The 1970 primary education operating costs were estimated at \$35 per child per year, and the total operating costs are projected to increase from \$384 million in 1970 to \$1218 million, in 1970 dollars, by 2010. (Figure 31, line 0). In addition, if the enrollment rate were to increase from 75.5 percent to 90 percent gradually over the next 30 years, and the cost of education were to double over the next 20 years and then remain constant, the annual operating cost of primary education by 2010 would be \$2903 million (Figure 31, line 1).

Changing the demographic conditions to those suggested in Figure 31, in addition to the improvements in educational conditions, shows that the annual educational cost in 2010 would be \$223 million more than with current (1970) fertility and mortality conditions and no improvement in educational enrollment rates or operating costs. But this total is still substantially less (by \$1462 million) than the projected operating costs with 1970 demographic conditions and improved educational conditions. It can also be demonstrated, using other parts of the PDG program, that a decrease in TFR and an increase in life expectancy at birth of the type suggested will have no appreciable effect on the labor force for at least two generations, and perhaps longer, if labor force participation rates improve due to the ability of the educational system to cope with the educational needs of the young population.

The above example has demonstrated one to the potential uses of the program in determining the consequences of both constant and changing parameters

for the educational system of the country. Should the student wish to make additional projections with different demographic or cost assumptions, these may be implemented immediately, and alternative patterns of development may be evaluated. No attempt is made here to draw any implications about the relationship between population growth and structural growth in Brazil. The purpose, rather, is to draw attention to the importance of population data and population education in the development of a country and to suggest the usefulness of interactive visual graphics for this task.

CONCLUSION

A review of the population education literature reveals the concern with which educators in the field view the progress of population education. Rather than adding to this concern at length, the purpose of this paper has been to transmit information about a new development in the state of the art. It is clear that the time of computer-assisted education has arrived in university curricula (Lyman, 1974) and is rapidly spreading to other environments. While the utilization of the PDG/CAI system is currently restricted to institutions with an interactive graphics terminal, this involves a large body of potential users and the number is increasing weekly. Developments in data management and computer technology have provided the educator with a new possibility: the ability to use his data and knowledge as a neutral tool in population education. Computer-assisted instructional resources, such as the PDG program described in this paper, are an important step in the ability of population educators, be they purists, propagandists or popularists (Rogers and Bauman, 1974: 10), to use the data and concepts of population.

In conclusion, it must be reiterated that this paper has attempted an extremely difficult task: to convey the workings of a dynamic interactional visual medium through a static written medium. It is up to the reader to imagine the dynamics that the process of pen on paper cannot convey.

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